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CHEMISTRY AND TECHNOLOGY OF FUELS AND LUBRICANTS
(SELECTED ARTICLES)

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CHEMISTRY AND TECHNOLOGY OF FUELS AND LUBRICANTS
(SELECTED ARTICLES)

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TABLE OF CONTENTS

	PAGE
1. Synthesis and Properties of Arylstearic Esters, by M. G. Rudenko, Yu. P. Sobolev, et. al.	1
2. Lessening the Corrosive Action of Anti-Abrasive Additives Without Impairing Their Effectiveness, by Yu. S. Zaslavskiy, G. I. Shor, et. al.	8

SYNTHESIS AND PROPERTIES OF ARYLSTEARIC ESTERS

M.G. Rudenko, Yu. P. Sobplev, M. S. Yatsenko,
L. B. Starikova

The first of the series of arylstearic acids to be synthesized was phenylstearic acid by Marcusson [1] in 1920 by condensations of benzene with oleic acid in the presence of $AlCl_3$.

There followed a number of papers on the improvement of the method of preparing phenylstearic acid proper as well as other acids in this series.

Arylstearic acids with the following aryl groups have been synthesized: phenyl, tolyl, naphthyl, phenoxyphenyl and others. For these only three esters have been reported: ethyl tolylstearate, methyl phenoxyphenylstearate, and methyl phenylstearate (not characterized) [2 through 8].

Among the number of patents that have been applied for is one for the application of arylstearic acids and their salts as additives to mineral oils [9].

The present paper is devoted to the synthesis and study of the properties of esters of arylstearic acids in order to explore the possibility of using them as synthetic lubricating oils.

We prepared phenyl, o-xylyl, and p-xylylstearic acids by condensation of commercial oleic acid with benzene, o-xylene, and p-xylene in the presence of AlCl_3 . The aromatic component in the reaction was taken in excess to oleic acid (5 to 1), while AlCl_3 and oleic acid were taken in equimolar amounts. The reaction was carried out at 80° for 5 to 6 hr. We purified the prepared arylstearic acids by distillation. In the arylation with naphthalene and diphenyl ether, trichlorobenzene was used as a solvent. Phenoxyphenylstearic acid, along with the above mentioned acids, was purified by distillation, but naphthylstearic acid was converted to methyl naphthylstearate immediately after being prepared and the stearate was later subjected to distillation. Of the acids prepared, phenoxyphenylstearic and o-xylylstearic had constants which differed from those given in the literature [6, 8].

	<u>o</u> -xylylstearic acid	phenoxyphenyl- stearic acid
boiling point at 0.015 mm, $^\circ\text{C}$	201-202	245-251
n_D^{20}	1.4975 (1.4936)	1.5198 (1.5263)
d_4^{20}	0.9388 (0.9336)	1.0032 (0.9964)
M_R	120.86 (121.1)	137.129 (138.09)
found	120.2 (120.2)	136.835 (136.72)
calculated		

(Data from the literature are given in parentheses)

The procedure followed enabled us to obtain higher yields for some arylstearic acids than those stated in the literature.

The yields of the arylstearic acids are listed below (%).

	Given in the literature	Obtained
p-xylylstearic	67 [8]	65
Naphthylstearic	17.5 [8]	32
Phenoxyphenylstearic	29 [6]	41
Phenylstearic	38 [6]	39

The commercial oleic acid used in the reaction contained a certain amount of impurities (linoleic and stearic acids), and because of this, upon fractional distillation of the reaction mixture stearic acid or its ester distilled first and only then the ester of the corresponding arylstearic acid or the acid itself. A large pot residue always remained. It was apparently a mixture of polysubstituted aromatic compounds with esters of polymers of linoleic acid, which appeared to be the reason for the low yields of arylstearic acids. Only in the case where xylol, a compound with two substituents in the ring, was used was a 65% yield of xylylstearic acid obtained.

The properties of the residue from methyl phenoxyphenylstearate were: solidification point = -20° ; $\nu_{100} = 35.70$; $\nu_{50} = 279$. The properties of the residue from methyl naphthylstearate were: solidification point = -5° ; $\nu_{100} = 55.0$; $\nu_{50} = 522$.

We prepared the methyl, benzyl, and 2-ethylhexyl esters of the phenylstearic, o-xylylstearic, n-xylylstearic, naphthylstearic, and phenoxyphenylstearic acids which we had prepared and examined their properties (Table 1).

Almost all of the esters had very low solidification points ranging from -40° to -60° . The benzyl naphthyl- and benzyl phenoxyphenylstearates have a somewhat higher solidification point of -35° , whereas the methyl esters of the same acids solidify at -40° to -50° . The situation with the esters of phenylstearic acids is peculiar; the methyl ester solidifies at -26° , and the benzyl ester at -50° , although the viscosity of the latter ($\nu_{50} = 19.32$) is much higher than the viscosity of the methyl ester ($\nu_{50} = 11.38$).

At the same time, the esters of stearic acid are solids and have a high solidification point. As an example of this, the benzyl ester

has a melting point of 45.8°, and the methyl ester, 38°.

TABLE 1

Properties of the esters of arylstearic acids

Esters of arylstearic acids	boiling point °C	Pressure mm Hg	n_D^{20}	d_4^{20}	MR_D		Solidification point °C
					Experimental	Calculated	
Methyl phenylstearate	178—183	0.1	0.9220	1.4825	115.93	115.70	-26
2-ethylhexyl phenylstearate	220—225	0.01	0.9038	1.4780	148.07	148.03	below -60
Benzyl phenylstearate	224—229	0.015	0.9587	1.5075	140.140	139.810	-50
Methyl p-xylylstearate	178—180	0.015	0.9259	1.4880	125.29	124.94	-50
Benzyl p-xylylstearate	230—237	0.02	0.9616	1.5105	148.89	149.05	-45
Methyl o-xylylstearate	186—188	0.015	0.9253	0.4886	125.41	124.94	-52
Benzyl o-xylylstearate	234—237	0.015	0.9597	1.5105	149.31	149.04	-50
Methyl naphthylstearate	220—224	0.02	0.9556	1.5220	135.53	131.04	-40
Benzyl naphthylstearate	242—252	0.015	0.9928	1.5400	158.24	155.15	-38
Methyl phenoxyphenylstearate	199—203	0.015	0.9825	1.5125	142.56	141.45	-50
Benzyl phenoxyphenylstearate	258—260	0.02	1.0068	1.5307	166.71	165.56	-35

The hypothesis has been previously stated that upon the arylation of oleic acid a mixture of isomers is obtained since an addition can take place at positions 9 and 10.

Harmon and Marvel [4] showed for the case of phenylstearic acid that it is actually a mixture of nearly equal parts of 9- and 10-phenylstearic acids. By malonic ester synthesis they obtained 9-phenylstearic acid with melting point of 36.5° to 38° and 10-phenylstearic acid with a melting point of 40° to 41.5°. The phenylstearic acid which these authors obtained from oleic acid was a liquid with a solidification point of about 0°; that obtained by us has a solidification point of -7°.

Thus, the lower solidification point of the esters of arylstearic acids prepared by us, compared with the esters of the stearic acids,

can be explained by the fact that they are not discrete compounds, but mixtures of isomers, and by the lowering of the solidification point upon the introduction of the aryl group. For example, the solidification point of stearic acid is 69.4° and that of 9-phenylstearic acid, 36.5° to 38°.

The viscosity of the esters (Table 2) increases for a particular acid with the increase in the number of carbon atoms in the alcohol, and for different acids with an increase in the molecular weight of the arylating reagent.

The viscosity of the esters of phenoxyphenyl stearic acid is lower than that of the esters of the naphthylstearic acid though the phenoxyphenyl radical is heavier than the naphthyl. In all probability this discrepancy is due to the ether function of the phenoxyphenyl radical.

The thermal oxidation stability of the arylstearates obtained was examined at 300° and with air bubbling through at the rate of 5 ml per minute for 10 hrs. The results of the tests are given in Table 3. Methyl phenoxyphenylstearate and benzyl *p*-xylylstearate gave better results by all indications in preventing corrosion of EI-347 steel. The test of thermal oxidation stability at 300° was conducted without the use of anti-oxidation and anti-corrosion additives.

In the oxidation of benzyl *p*-xylylstearate with the addition of .5% AzNII-10 there was observed a decrease in volatility from 16.5% to 3.6% and a decrease in corrosion of EI-347 steel from 162.4 g/m² to 0.0.

This data indicates that when matched with corresponding additives benzyl *p*-xylylstearate and methyl phenoxyphenylstearate can be used

as lubricating materials or components of lubricating materials at 300°.

TABLE 2
Kinematic Viscosity of Esters of Arylstearic Acids

Esters of arylstearic acids	100°	50°	Temperatures below zero
Methyl phenylstearate	3.70	11.40	451 (-20°)
2-ethylhexyl phenylstearate	5.4	19.20	15900 (-40°)
Benzyl phenylstearate	5.55	19.30	5500 (-30°)
Methyl p-xylylstearate	4.98	19.00	11600 (-35°)
Benzyl p-xylylstearate	5.95	30.50	28300 (-30°)
Methyl o-xylylstearate	5.20	21.10	13500 (-35°)
Benzyl o-xylylstearate	7.40	31.00	24300 (-30°)
Methyl naphthylstearate	7.20	33.50	14300 (-25°)
Benzyl naphthylstearate	9.90	51.10	66000 (-35°)
Methyl phenoxyphenylstearate	6.50	27.50	17600 (-30°)
Benzyl phenoxyphenylstearate	9.00	41.60	22500 (-25°)

TABLE 3
Thermal Oxidation Stability of Esters of Arylstearic Acids at 300° for a Period of 10 hours

Esters of arylstearic acids	acid number, mg KOH		Precipitate %	Volatility %	Corrosion of metals, g/m ²	
	initial	after oxidation			EI-347	AK-4
Methyl phenylstearate	0.34	24.00	0.072	11.4	-104.7	0.0
Methyl o-xylylstearate	0.51	25.35	0.084	6.6	-27.6	-0.54
Methyl p-xylylstearate	0.45	26.52	0.087	10.1	-90.4	-0.51
Benzyl p-xylylstearate	0.93	4.95	0.017	16.5	-162.4	0.0
Methyl phenoxyphenylstearate	0.54	18.2	0.03	4.5	-3.1	0.0
P. residue of methyl naphthylstearate	1.22	14.90	0.1	7.9	-51.4	0.0

Conclusions

1. A method for preparing phenyl, p-xylyl, o-xylyl, naphthyl,

and phenoxyphenylstearic acids has been developed.

2. Methyl, 2-ethylhexyl, and benzyl phenylstearate; methyl and benzyl p-xylyl- and o-xylylstearate; methyl and benzyl naphthylstearate; and benzyl phenoxyphenylstearate were prepared for the first time and their properties were examined.

3. All the esters of arylstearic acids prepared have low solidification points and a gently sloping viscosity - temperature curve.

4. The esters of arylstearic acids were tested for thermal oxidation stability at 300° for a period of ten hours. The best results were obtained for methyl phenoxyphenylstearate and benzyl p-xylylstearate. When matched with the corresponding anti-oxidation and anti-corrosion additives the esters mentioned can be used as lubricating materials or components of lubricating materials at a temperature of 300°.

REFERENCES

1. Marcusson J. Z. Angew. Chem., 33, 234, 1920.
2. Nicolet H., Milt C. J. Amer. Chem. Soc. 49, 1103, 1927.
3. Schmidt E. G. J. Amer. Chem. Soc., 52, 1172, 1930.
4. Harmon J., Marvel C. S. J. Amer. Chem. Soc., 54, 2515, 1932.
5. McKee R. H., Faber H. B. U. S. patent 1972568 (1934); Chem Zentr., 11, 384, 1934.
6. Stirton A. J., Peterson B. F. Ind. Eng. Chem., 31, 856, 1939.
7. Kimura W., Omura T., Taniguchi H. Ber., 71, 2686, 1938.
8. Stirton A. J., Schaeffer B. B., Stavitzke A. A., Weil J. K., Waldo C. J. Amer. Oil Chem. Soc., 25, 365, 1948.
9. U. S. patent 2043836, C. A. 30, 5406, 1936; 2095538, C. A. 31, 8914, 1937; 2106247, C. A., 32, 2732, 1938; 1850561, Chem. Zentr. 1, 3252, 1932.

LESSENING THE CORROSIVE ACTION OF ANTI-ABRASIVE
ADDITIVES WITHOUT IMPAIRING THEIR EFFECTIVENESS

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A. I. Kuznetsova, F. B. Lebedeva

The radiological studies performed have enabled us to formulate a clear statement of the essential difference in the requirements that must be met for the chemical compounds when matching anti-corrosive and anti-abrasive oil additives. This difference is summed up in the fact that anti-corrosive additives must have stable sulfur phosphorus bonds in their molecules, while the anti-abrasive additives should easily eliminate sulfur, phosphorus, or chlorine in order to form the appropriate sulfide, phosphide, or chloride of the metal at high contact temperatures [5-7]. Such an essential difference in the aforementioned properties of the additives explains the maximum anti-abrasive effectiveness which many authors have set for chemically active compounds that have a corrosive effect upon the metals which they protect from abrasion [8,9]. The most effective anti-abrasive additives can be obtained not only with the combination of chemical compounds in normal use, which would provide a satisfactory anti-abrasive effect with a minimum of corrosion [10-12], but also by matching of additives which combine the most effective anti-abrasive and anti-corrosive components. With such a composition of additives, it is apparently possible to eliminate an effect observed last time [13] in which the activity of the anti-abrasive additives is

delayed when they are used in friction-producing units of high-speed mechanisms. This effect is related to the fact that anti-abrasion additives are usually devised on the basis of a calculation of their chemical activity toward the metal of the surfaces of friction only after the additives have decomposed after being heated to certain high temperatures. It is assumed that the occurrence of such high temperatures on portions of the rapid-heating surfaces of friction will bring about the decomposition of some amount of additive near the heat-producing zone, while the main supply of additive remains unchanged in the volume of the oil. Apparently, in high speed mechanisms not enough time is provided at the surfaces of friction for decomposition of the additive and reaction of the decomposition products with the metal surfaces. This must be taken into account in the development of a composition for anti-abrasive additives.

For the study and selection of two-component additives under laboratory conditions we have devised radiological methods of determining the chemical activity of anti-abrasive additives in oil in the presence and absence of friction. The chemical activity of anti-abrasive additives, which determines their reactivity in connection with the metal which they protect from abrasion and seizing, and which thereby determines their anti-abrasive effectiveness [12, 14, 15], is appraised by determining the kinetics of the dissolving in oil of radioactive steel (irradiated with neutrons to Fe^{59}) or copper (activated by introducing tracer amounts of Ag^{110} into the molten copper) under the action of the additive being tested [1, 2, 16].

We studied the chemical activity with respect to radioactive copper and steel of various organic compounds of sulfur and chlorine which have found application as anti-abrasive additives. As an example, we have listed in Fig. 1 the results of a radiometric determination of the chemical activity of chlorinated paraffin, the sulfur-containing additive Lz-6/9, and their mixtures, as well as a mixture of dibenzyldisulfide and chlorinated paraffin all of which had been

added to DC-14 oil. This determination was made with a copper plate at a temperature of 150° . In Fig. 1 we see that the chemical activity of the sulfur-containing additive and the chlorinated paraffin is considerably less than the chemical activity of their mixtures.

It is also seen that the mixture of dibenzyl-disulfide and chlorinated paraffin possesses a very high chemical activity, a fact which is also noted in the other papers [12]. According to data from tests on a four-ball apparatus this mixture provides the highest anti-abrasive effect.

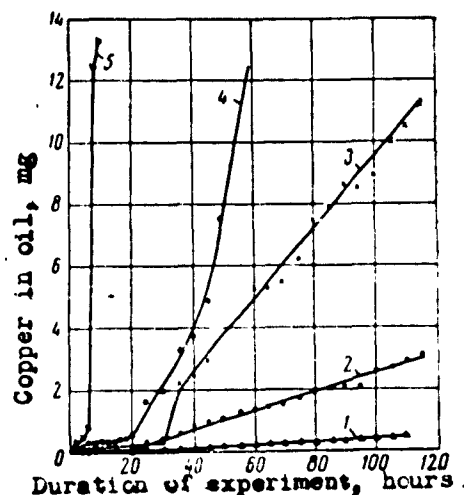


Fig. 1. Corrosion of a radioactive copper plate under the action of oil DC-14 with various anti-abrasive additives. Filkevich apparatus, oil temperature 150° .

- 1) Oil DC-14; 2) DC-14 oil with 7% chlorinated paraffin; 3) DC-14 with 5% LZ-6/9;
- 4) DC-14 with 5% LZ-6/9 and 7% chlorinated paraffin; 5) DC-14 with 5% dibenzyl-disulfide and 7% chlorinated paraffin.

Various additives were introduced into the oil along with the dibenzyl-disulfide and chlorinated paraffin for the selection of the anti-corrosion component. Several of them provided a decrease in corrosion with copper and steel. In Table 1 are listed the results of the radiometric determinations and the data from the tests on the four-ball machine for an oil of selective

refinement (with a viscosity, $\nu_{100} = 14$ cs) with the most effective of the anti-corrosion additives tested, 1-L*. As seen in Table 1, the addition of

TABLE

Sample	Corrosion, mg		Results of tests on four-ball machine, maximum stress before jamming, kg
	copper at 150° for 10 hours	steel at 200° for 75 hours	
Oil of selective refinement with viscosity, $\nu_{100} = 14$ cs	0,03	—	79
The same + 3% dibenzyl disulfide + 7% chlorinated paraffin	15,6	0,18	126
The same + 3% dibenzyl disulfide + 7% chlorinated paraffin + 6% additive "1-L"	0,8	0,042	126

additive 1-L sharply decreases the corrosive action of the oil with additives without impairing the anti-abrasive properties. However, the additive provides effective anti-corrosive action with copper under the conditions of the test only for a period of 10 hrs.

Along with the empirical selection of anti-corrosion components, we also conducted a radiometric study of the anti-corrosive properties of phosphorus-containing compounds, proceeding on the assumption that effective protection of the metal surfaces from corrosion by chlorine and sulfur atoms can be attained via the creation of, not a molecular, but a more coherent atomic film through which it is more difficult for the mobile chlorine and sulfur atoms to penetrate to reach the surface. It was assumed that such an atomic film might be obtained using phosphorus compounds. This assumption was based on data obtained by us

* Barium alkylphenoxide in a solution of hydroxypropylated alkylphenol.

previously concerning the fact that the phosphides of the metals, in contrast to the sulfides, were insoluble products of the oxidation of the oils, and are, therefore, held firmly on the surface of the metals for a long time [1-4]. Our attention last time was devoted to this as well as to other research [12]. For this, it is necessary that the phosphorus-containing compounds be soluble in the appropriate oil and that they eliminate phosphorus at a temperature considerably lower than that of decomposition of the anti-abrasive components. It was assumed, in addition to that, that the formation

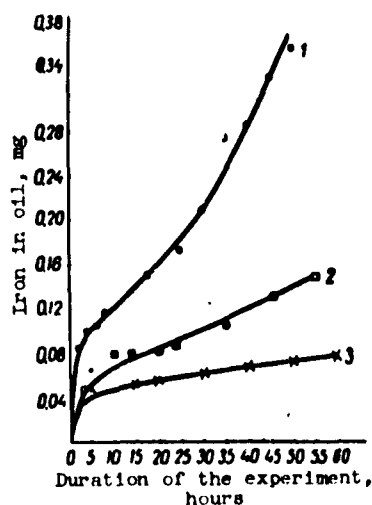


Fig. 2. Corrosion of radioactive steelplates under the action of an oil containing anti-abrasive additives and various anti-corrosion phosphorus-containing compounds. Pinkevich apparatus, oil temperature 200°. 1) oil of selective refinement with viscosity $\nu_{100} = 14$ cs + 3% dibenzyl disulfide + 7% chlorinated paraffin; 2) the same + 3% phosphorus-containing additive DF-9; 3) the same + 0.5% triphenyl phosphite.

on the surface of the metal of a phosphide, having an anti-wear effect, would not impair the effectiveness of the anti-abrasive components.

As is seen in Fig. 2, the addition of phosphorus additives assures a significant reduction in the corrosion of steel (at an oil temperature of 200°) under the action of a mixture of dibenzyl disulfide and chlorinated paraffin. In this way, according to the data from tests on the four-ball machine, the anti-abrasive effectiveness is not impaired. Listed below are the results of radiometric determinations of the corrosion of steel at an oil temperature of 200°.

	Corrosion of steel in 6 hrs, counts/min
Oil DC-14	32
DC-14 + 3% LZ-6/9 + 7% chlorinated paraffin	1648
The same + 0.5% tricresyl phosphate	1832
The same + 0.5% triphenyl phosphite	80

The difference in temperature of decomposition (elimination of phosphorous) of triphenyl phosphite and tricresyl phosphate was evidenced by the effectiveness of the anti-corrosive action of these compounds in composition with a chemically active mixture of anti-abrasive components.

Tricresyl phosphate gave no anti-corrosive effect, while triphenyl phosphite provided a sharp decrease in corrosion. The proposed application of phosphorus-containing anti-corrosive components in composition with the most chemically active anti-abrasive additives can enable us to use as highly effective additives chemical compounds which have previously been rejected due to their high corrosive activities. The chemical interaction of the surfaces of friction with anti-abrasive additives, which prevent and lessen abrasion and seizing under conditions of high stress and contact temperatures, can in the presence of small and moderate stresses give rise to chemical wear, in some cases considerably exceeding that produced during operation on oils without additives.

Tests of an oil with anti-abrasive additives were conducted on a machine the friction-producing unit of which (Fig. 3) consisted of two hollow, cast-iron cylinders, with rubbing ends (10 mm in external diam.), one of which was radioactive [17]. The tests were conducted at 600 rpm with a force of 2.5 kg/cm^2 for a duration of 1 hour. The experiment was repeated many times and for an indication of the wear the average value of the wear from the data of all the parallel experiments was taken.

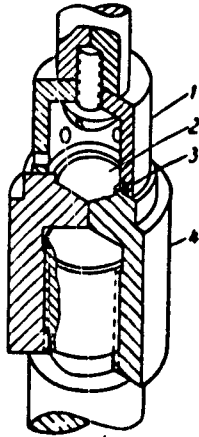


Fig. 3. Diagram of the friction-producing unit of the machine.
1) radioactive sample subjected to friction; 2) reservoir for the oil; 3) insert of cobalt-60; 4) non-radioactive sample subjected to friction.

Average value of wear,
counts/min

DC-14, 9 experiments.....	660
DC-14 + 3% LZ-6/9 + 7% chlorinated paraffin, 9 experiments.....	1920
DC-14 + 3% LZ-6/9 + 0.5% triphenyl phosphite, 5 experiments.....	840

From the list of results we see that the addition of anti-abrasive additives to DC-14 sharply increased wear on the friction surfaces. The use of these additives in composition with triphenyl phosphite (done to eliminate corrosion as previously shown) insures that the level of wear on the surfaces of friction will be equal to the level of the wear which takes place when operating on oil without additives.

Thus, it has been experimentally proven that the use of phosphorus compounds as anti-corrosive components in composition with anti-abrasive additives not only sharply reduces corrosion, but also provides a decrease in chemical wear on the surfaces of friction with low stresses.

REFERENCES

1. Yu. S. Zaslavskiy, G. I. Shor, B. N. Sheverova. The mechanism of the protection of surfaces of friction from corrosive wear with oil additives, Trudy Tret'yey Vsesoyuznoy Konferentsii po Treniyu i Iznosy v Mashinakh, Acad. Sci. USSR Press, 3, pp. 348-56, 1961.

2. Yu. S. Zaslavskiy; G. I. Shor; R. N. Shneiderova. A Study of the Mechanism of the Protection of Surfaces of Friction from Corrosive Wear, Reports of the Soviet Scientists to the Second International Conference on the Peaceful Use of Atomic Energy in Geneva 1-13, Sept. 1958, Preparation and Use of Isotopes, Atomizdat, 6, pp. 148-159, 1959.
3. Yu. S. Zaslavskiy; S. E. Kreyva; G. I. Shor; R. N. Shneiderova. On the Nature of Corrosive Films Formed by Anti-corrosive Motor Oil Additives, Khimiya i Tekhnologiya Topliv i Masel, No. 12, 29-35, 1959.
4. Yu. S. Zaslavskiy; G. I. Shor; R. N. Shneiderova. The Mechanism of the Destruction of Protective Films Formed by Anti-corrosive Additives, Reports Acad. Sci. USSR, 128, No. 5, 1010-1011, 1959.
5. Yu. S. Zaslavskiy; G. I. Shor. Radiological Control of the Operational Quality of Oil Additives, Transactions of the All-Union Conference for the introduction of Radioactive Isotopes and Nuclear Radiation into the National Economy of the USSR, Gostoptekhnizdat, 1, pp. 329-337, 1961.
6. Yu. S. Zaslavskiy; G. I. Shor. Radiological Methods for Investigating the Operational Properties of Lubricating Oils, Report No. RICC/305 to the International Conference on the Use of Radioisotopes in the Physical Sciences and in Industry in Copenhagen 6-17 September 1960, MAGATE Press, Vienna, 1961.
7. Yu. S. Zaslavskiy; G. I. Shor; R. N. Shneiderova. On the Reaction Mechanism of some Types of Oil Additives (Cleaning, anti-corrosion, and Anti-abrasive Additives), Transactions of the All-union Scientific-Engineering Conference on Oil and Fuel Additives, Gostoptekhnizdat, 1961.
8. W. Davey, E. D. Edwards. The Extreme-pressure Lubricating Properties of Some Sulphides and Disulphides in Mineral Oils, as Assessed by the Four-Ball Machine. Wear, 1, No. 4, 291-304, 1958.
9. Palcari, A. Girelli, S. Sinigaglia. Evaluation of Antiseizing and Recovery-From-Seizure Properties of E.-P. Lubricants by the Four-Ball Testing Machine. J. of the Institute of Petroleum, 44, No. 414, 178-81, 1958.
10. G. V. Vinogradov. The use and Reaction Mechanism of Phosphorus-containing Organic Compounds as Anti-wear Oil Additives, The Chemistry and Application of Phosphorus-containing Organic Compounds, Acad. Sci. USSR Press, pp. 124-47, 1957.
11. J. S. Elliot, N. E. Hitchcock, E. D. Edwards. Hypoid Gear Lubricants and Additives. J. of the Institute of Petroleum, 45, No. 428, 219-235, 1959.
12. F. T. Barcroft. A Technique for Investigating Reactions Between A. P. additives and Metal Surfaces at High Temperatures, Wear, 3, No. 6, 413-500, 1960.
13. G. V. Vinogradov; Yu. Yal Polgl'skiy; M. V. Bezborod'ka. The Use of Machines with Precision-fitted Friction-producing Units for Appraisal of Metal wear, and the Anti-wear and Anti-friction Properties of Lubricating Materials. Transactions of the Conference on Wear Testing Methods, 7-10 December 1960, Acad. Sci. USSR Press, 1961.

14. R. B. Campbell; L. Grunberg. Study of Reactions of Metals with Sulfur and Phosphorus Compounds by Pulsed Temperatures. Report No. RICC/32 to the International Conference on the use of Radioisotopes in the Physical Sciences and Industry in Copenhagen September 6-17, 1960, MAGATE Press, Vienna, 1961.
15. G. Hugel. Chemical Nature of Extreme Pressure Lubrication. Lubrication Engineering, 14, No. 12, 523-526, 1958.
16. Yu. S. Zaslavskiy; G. I. Shor; A. N. Paseshnichenko; T. B. Lebedeva. Radiological Methods for Investigating the Anti-wear Properties of Lubricating oils, Transactions of the Conference on Wear Testing Methods, December 7-10, 1960, Acad. Sci. USSR Press, 1961.
17. Yu. S. Zaslavskiy; G. I. Shor; R. N. Shneyerova. Technique for the Selection of Effective Anti-abrasive Oil Additives, Petroleum Engineering News, Processing, No. 1, 10-12, 1960.

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